

Ivory Crisp: A Potato Variety with High Tuber Solids and Cold Chipping Ability

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ABSTRACT

Ivory Crisp was released in 2002 by the experiment stations of Idaho, Oregon, Washington, and North Dakota, and by the USDA/ARS. It resulted from a 1980 cross of ND292-1 and A77268-4. Ivory Crisp is suited for use in both the direct delivery and storage chipping markets. Ivory Crisp is a medium-maturing potato variety with round, white tubers and excellent chipping quality. It has medium to high yield potential, high tuber solids, resistance to most internal and external tuber defects, and the ability to chip from cold storage. In trials in Idaho, Oregon, and Washington, total and U.S. No. 1 tuber yield of Ivory Crisp was similar to Atlantic but lower than Chipeta. Yield of tubers in the size range 113–336 g for Ivory Crisp is higher than for either Atlantic or Chipeta. Ivory Crisp is resistant to growth cracks, secondary growth, hollow heart, and stem-end necrosis, but susceptible to shatter bruise. Tuber sugar content has consistently remained low following cold storage and near-acceptable chip color retained at 4.4 C. Ivory Crisp is susceptible or moderately susceptible to most common field diseases of potato. It is highly susceptible to common scab, powdery scab, and pink rot. Tubers of Ivory Crisp have dry matter content (22.4%) lower than those of Atlantic, but higher than those of

Chipeta. Glycoalkaloid content of Ivory Crisp tubers is very low (4.3 mg 100 g⁻¹). An application for Plant Variety Protection has been filed for Ivory Crisp. Seed is available from potato seed growers in Idaho, North Dakota, and Canada. Small amounts of seed, for research purposes, can be obtained by contacting the corresponding author.

RESUMEN

La variedad de papa Ivory Crisp fue liberada en el año 2002 por las estaciones experimentales de Idaho, Oregon, Washington y North Dakota y por el USDA/ARS. Fue el resultado de un cruzamiento en 1980 de ND292-1 y A77268-4. Ivory Crisp es apropiado tanto para usarlo en entrega directa como para los mercados que venden papa cortada almacenada. Es una variedad de maduración en tiempo medio, con tubérculos redondos, blancos y una excelente cualidad de picado. Tiene un potencial de rendimiento mediano a alto, contenido alto de sólidos, resistente a la mayoría de defectos internos y externos del tubérculo, los cuales tienen la propiedad de que pueden ser picados después de extraídos de almacenaje frío. En pruebas hechas en Idaho, Oregon y Washington, el rendimiento total de tubérculos de Ivory Crisp US.No.1 fue similar al de Atlantic, pero más bajo que el de Chipeta. El rendimiento de tubérculos en un rango de 113 a 336g de Ivory Crisp es más alto que el de Atlantic o de Chipeta. Ivory Crisp es resistente a las grietas de crecimiento, al crecimiento secundario, corazón vacío y necrosis de la base del tallo, pero es susceptible a las magulladuras causadas por golpes. El contenido de

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Abbreviations: RHSCC = Royal Horticulture Society Color Chart.

azúcar del tubérculo ha permanecido bajo después del almacenaje en frío y ha sido retenido un color más aceptable a 4.4 C. Ivory Crisp es susceptible o moderadamente susceptible a las enfermedades de campo más comunes. Es muy susceptible a la sarna común, roña y pudrición rosada. Los tubérculos de Ivory Crisp tienen un contenido de materia seca (22.4%) inferior al de Atlantic, pero más alto que el de Chipeta. El contenido de glicoalcaloide de los tubérculos de Ivory Crisp es muy bajo ($4.3\text{mg}/100\text{g}^{-1}$). Una solicitud para la protección de esta variedad ha sido registrada. Los productores de semilla de papa de Idaho, North Dakota y Canada tienen semilla disponible. Con propósitos de investigación se pueden obtener pequeñas cantidades de semilla contactándose con el autor respectivo.

INTRODUCTION

Ivory Crisp, released by the experiment stations of Idaho, Oregon, Washington, North Dakota, and the USDA Agricultural Research Service in 2002 originated from the cross ND292-1 x A77268-4 made at North Dakota State University in 1980 (pedigree is provided in Figure 1). ND292-1 is a North Dakota seedling with Sable (Davies and Young 1966), Norchip (Johansen et al. 1969), and Lenape (Akeley et al. 1968) in its pedigree. A77268-4 is a USDA/ARS (Aberdeen, Idaho) seedling with Lemhi Russet (Pavek et al. 1981) and Norchip in its pedigree. Ivory Crisp was introduced into Oregon from North Dakota in 1984 as a seedling tuber. It was first selected at Powell Butte, Oregon and went through 4 years of evaluation in the Oregon statewide trials. In 1988 to 1990 and 1994, Ivory Crisp was included in the Western Regional Chipping Trial. Prior to release, seed increases and commercial trials were conducted in Idaho.

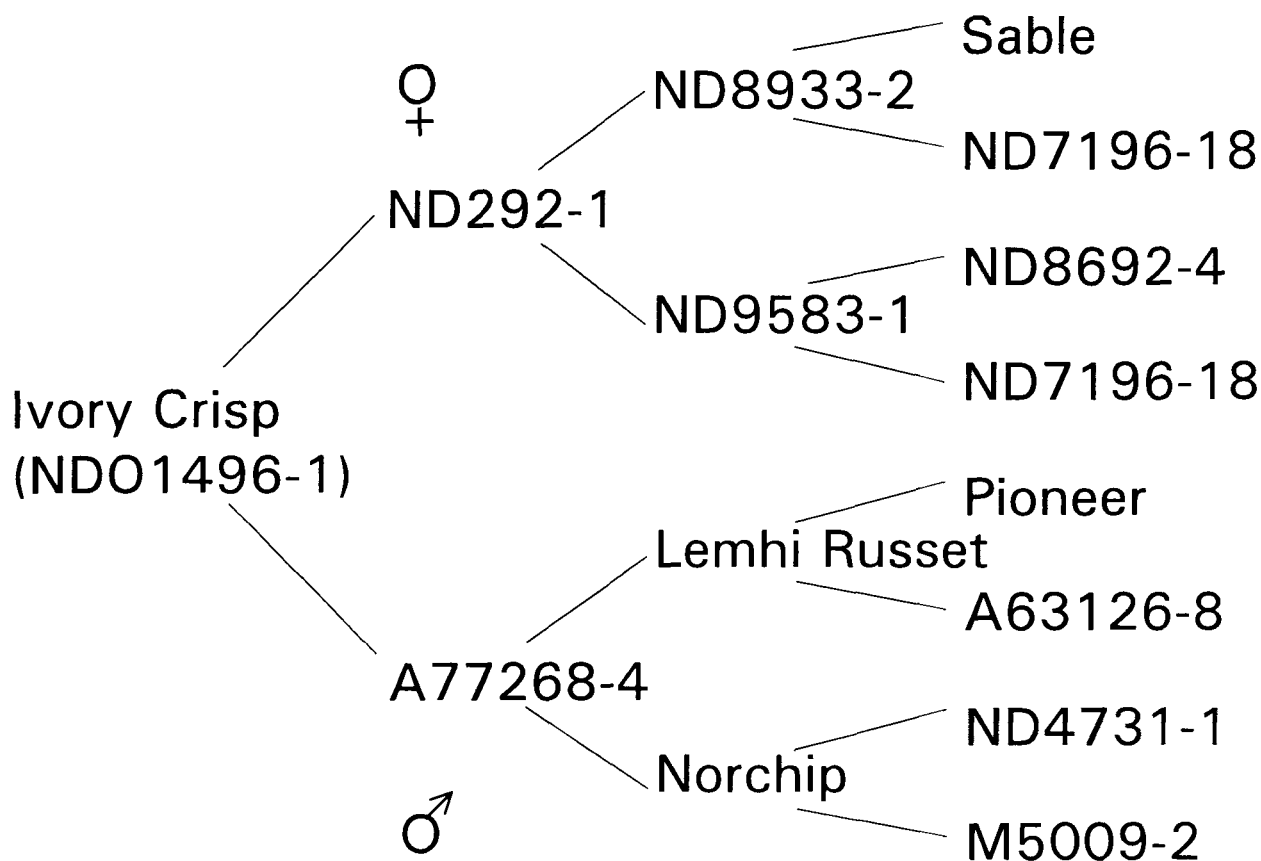


FIGURE 1.
Four-generation pedigree of Ivory Crisp.

VARIETAL DESCRIPTION

Pictures of plants, inflorescence, tubers, and light sprouts of Ivory Crisp are presented in Figure 2.

Plant, Vine, and Foliage Descriptors

Growth habit: Medium-sized, spreading vine; medium maturity (111 to 120 days), similar to Atlantic and 10-20 days earlier than Chipeta. *Stems:* moderate number, generally small in diameter, anthocyanin pigmentation absent; stem nodes not swollen; prominent stem wings ($\cong 3$ mm wide) with wavy margins. *Leaves:* small to medium-sized; yellow-green (Royal Horticulture Society Color Chart [RHSCC] 146B); closed to moderately open silhouette; no anthocyanin pigmentation on the petioles and midribs. *Terminal leaflets:* broadly ovate shape with an acuminate tip and cordate base; slightly wavy margins; average length 100 mm, width 61 mm (100 leaves). *Primary leaflets:* 3 to 5 pairs with a mean of 4.1 pairs; medium ovate shape with an acuminate tip and cordate base. *Secondary leaflets:* 0 to 4 pairs, mean 2.5 pairs. *Tertiary leaflets:* 0 to 4 pairs, mean 0.7 pairs. *Stipules:* medium-sized, clasping.

Flower Descriptors

Inflorescence: Abundant, averaging 3.7 inflorescences per plant and 20.2 flowers per inflorescence. *Buds:* weak reddish-brown anthocyanin pigmentation on the buds but absent on the pedicels; moderate pubescence on the calyx and pedicel; pedicel articulation slightly prominent; buds seldom abort. *Calyx:* sepals awl-shaped, fused to one-half the length of the bud. *Corolla:* pentagonal to rotate shape; white (RHSCC 155A) on both inside and outside surfaces; medium large, mean width 38 mm. *Anthers:* Dark yellowish-orange color (RHSCC 17B); arranged in a narrow cone. *Stigma:* capitate, yellow-green color (RHSCC 146B). *Pollen:* Abundant, fertile. *Fruit:* moderate to heavy production in the field.

Tubers Descriptors

Tubers: Round to slightly oval shape; slightly compressed; mean length 76 mm, range 55 to 92 mm; mean width 79 mm, range 68 to 93 mm; mean thickness 63 mm, range 53 to 73 mm (measured tubers ranged between 168 and 336 g). *Skin:* white to buff (RHSCC 158B); not scaly. *Eyes:* apical eyes intermediate in depth, lateral eyes shallow; slightly prominent eyebrows; predominantly apical in distribution; moderate number, mean per tuber 13.3, range 9 to 26. *Flesh:* white to

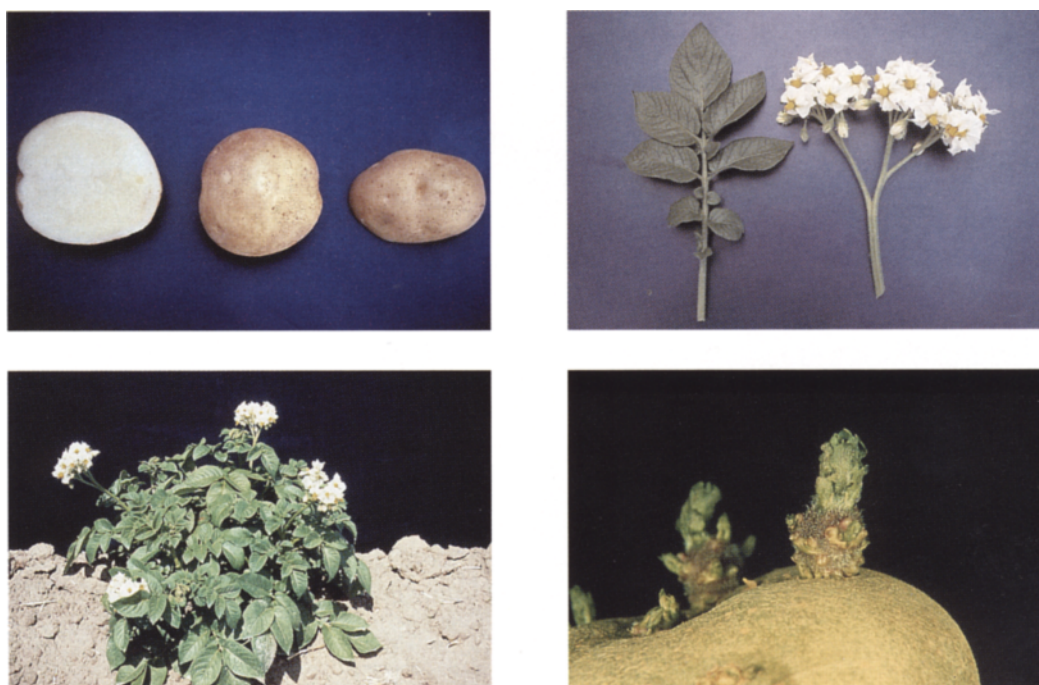


FIGURE 2. Pictures of Ivory Crisp tuber (A), plant (B), leaf and inflorescence (C), and light sprout (D).

slightly cream colored (RHSCC 158D); slightly prominent pith region. *Dormancy*: short to medium, similar to Atlantic. *Light sprout*: weak to moderate brownish-red anthocyanin pigmentation; spherical; slightly open bud scales; moderately

pubescent base with slightly hirsute bud scales; rapid rate of development.

TABLE 1—Total and U.S. No. 1 tuber yield and tuber specific gravity of Ivory Crisp and Atlantic potatoes grown in late-harvest trials in Idaho, Oregon, and Washington between 1988 and 1994.

Variety	Year	Tuber Yield			Specific Gravity ¹
		Total	U.S. No. 1	113-336g	
		- Mg ha ⁻¹ -	- Mg ha ⁻¹ -	- Mg ha ⁻¹ -	
Idaho²					
Ivory Crisp	1988	43.2	37.5	24.8	1.094
	1989	37.1	28.1	24.5	1.089
	1990	36.8	20.8	20.4	1.089
	1994	40.3	32.5	27.6	1.088
Atlantic	1988	47.4	39.1	20.5	1.085
	1989	34.5	23.5	20.9	1.090
	1990	42.3	35.6	34.0	1.096
	1994	42.0	34.3	23.1	1.092
Oregon³					
Ivory Crisp	1988	64.6	50.7	39.3	1.086
	1989	55.0	42.7	24.2	1.078
	1990	71.1	60.1	50.3	1.078
	1994	71.8	59.9	50.0	1.079
Atlantic	1988	62.0	53.9	38.9	1.089
	1989	72.1	59.1	39.2	1.079
	1990	79.0	67.4	47.6	1.084
	1994	67.4	59.4	38.1	1.082
Washington⁴					
Ivory Crisp	1988	60.0	53.4	45.5	1.091
	1989	75.5	60.3	33.2	1.081
	1994	37.1	23.5	22.8	1.087
Atlantic	1988	56.0	42.6	28.1	1.087
	1989	81.4	70.3	41.7	1.087
	1994	24.3	17.7	10.3	1.090
Overall Mean					
Ivory Crisp		53.9	42.7	33.0	1.085
Atlantic		55.3	45.7	31.1	1.088

¹Tuber specific gravity determined using the weight-in-air/weight-in-water method.

²Trials conducted by Dr. Stephen Love, University of Idaho, at Aberdeen, Idaho.

³Trials conducted by Dr. Dan Hane, Oregon State University, at Hermiston, Oregon.

⁴Trials conducted by Dr. Robert Thornton, Washington State University, at Othello, Washington.

Agronomic Performance

Ivory Crisp was evaluated for 4 years in Western Regional chipping trials. Overall, total yield of Ivory Crisp was 3% lower than that of Atlantic, U.S. No. 1 yield was 7% lower, and yield of tubers weighing 113 to 336 g (comparable to 1 7/8 to 3 1/2 in diameter) was 6% higher (Table 1). In the Idaho and Oregon trials, Atlantic produced higher mean yields than Ivory Crisp, while in Washington, the opposite was true. The yield advantage in Washington was, in part, due to a poor performance by Atlantic in 1994.

In early harvest trials grown at Hermiston, Oregon, Ivory Crisp produced slightly lower total and U.S. No. 1 yields, and also a lower yield of 113 to 336 g tubers, in comparison with Atlantic (Table 2). The average number of days from planting to harvest in the early trials was 116 days.

In late harvest trials at Aberdeen and Rexburg, Idaho, on average Ivory Crisp produced higher tuber yields than Atlantic, but lower yields than Chipeta (Table 3). Compared with Chipeta, Ivory Crisp was 19% lower for total yield, 29% lower for U.S. No. 1 yield, but slightly higher for yield of tubers between 113 and 336 g.

TABLE 2—Total and U.S. No. 1 tuber yield and tuber specific gravity of Ivory Crisp and Atlantic potatoes grown in early-harvest trials at Hermiston, Oregon.¹

Variety	Year	Tuber Yield			Specific Gravity ²
		Total	U.S. No. 1	113-336g	
		- Mg ha ⁻¹ -	- Mg ha ⁻¹ -	- Mg ha ⁻¹ -	
Annual Means					
Ivory Crisp	1988	53.2	36.6	34.4	1.091
	1989	52.0	29.2	26.3	1.081
	1994	57.0	43.0	42.4	1.092
Atlantic	1988	50.6	35.0	32.3	1.088
	1989	55.3	36.2	33.0	1.083
	1994	58.6	44.4	40.8	1.096
Overall Means					
Ivory Crisp		54.1	36.3	34.4	1.088
Atlantic		54.9	38.5	35.4	1.089

¹Trials conducted by Dr. Dan Hane, Oregon State University, at Hermiston, Oregon.

²Tuber specific gravity determined using the weight-in-air/weight-in-water method.

TABLE 3—Total and U.S. No. 1 tuber yield and tuber specific gravity of Ivory Crisp, Atlantic, and Chipeta potatoes grown in late-harvest trials at Aberdeen and Rexburg, Idaho.

Variety	Year/Loc ¹	Tuber Yield			Specific Gravity ²	Hollow Heart ³	Chip Color ⁴	
		Total	U.S. No. 1	113-336g			4.4 C	10.0 C
		- Mg ha ⁻¹ -	- Mg ha ⁻¹ -	- Mg ha ⁻¹ -		- % -		
Trial Means								
Ivory Crisp	1988A	43.2	37.6	24.6	1.094	2	1.3	1.0
	1989A	37.1	28.2	24.5	1.089	0	2.6	1.0
	1991R	38.5	30.8	23.9	1.095	0	2.4	1.0
	1992A	50.2	42.1	36.1	1.095	0	4.0	1.0
	1992A	49.3	36.5	34.0	1.094	0	3.3	1.0
	1992R	49.1	36.3	30.4	1.092	3	3.0	1.0
	1993A	36.6	30.4	27.5	1.102	0	2.2	1.0
	1993R	36.4	27.7	24.4	1.089	2	2.5	1.0
	1994A	40.3	32.7	27.8	1.088	0	2.1	1.1
	1995A	47.4	33.6	31.3	1.092	0	1.8	1.0
	1996A	47.0	42.3	33.4	1.095	0	3.4	1.0
Atlantic	1988A	47.4	39.3	20.8	1.095	40	1.8	1.5
	1989A	34.5	23.5	21.0	1.090	0	3.1	1.6
	1991R	35.4	28.0	20.9	1.095	15	2.4	1.1
	1992A	45.8	41.7	36.6	1.097	0	4.2	2.2
	1992A	47.3	43.0	34.0	1.097	0	4.0	2.1
	1992R	54.3	41.3	32.0	1.099	13	3.0	1.0
	1993A	22.1	18.1	16.5	1.101	13	3.6	2.0
	1993R	32.4	20.4	15.2	1.093	17	3.3	1.6
	1994A	42.0	34.4	23.1	1.092	43	2.8	1.8
	1995A	43.9	33.4	29.0	1.097	25	2.7	2.2
	1996A	40.9	34.3	32.7	1.097	0	3.5	1.2
Chipeta	1988A	50.3	43.2	26.7	1.094	2	1.8	1.4
	1989A	50.8	45.8	34.6	1.087	3	3.0	1.1
	1991R	43.8	30.7	19.3	1.089	3	3.1	1.4
	1992A	58.4	55.4	34.4	1.084	3	4.0	1.9
	1992A	59.7	56.1	33.4	1.085	3	4.0	2.0
	1992R	49.4	40.0	33.1	1.088	0	3.4	1.0
	1993A	44.5	40.9	32.0	1.095	3	3.1	1.5
	1993R	46.4	33.5	23.2	1.090	3	3.3	1.3
	1994A	61.8	50.7	21.0	1.083	3	3.2	1.4
	1995A	51.4	44.2	26.2	1.086	13	3.1	2.1
	1996A	46.8	44.5	27.6	1.088	0	3.9	1.0
Overall Means								
Ivory Crisp		43.2	34.4	28.9	1.093	1	2.6	1.0
Atlantic		40.5	32.5	25.6	1.096	15	3.0	1.7
Chipeta		51.2	44.1	28.3	1.088	3	3.3	1.5

¹Locations: A = Aberdeen, Idaho, experiment station site; R = Rexburg, Idaho, grower field. In 1992, there were two separate trials at Aberdeen.

²Tuber specific gravity determined using the weight-in-air/weight-in-water method.

³Hollow heart and/or brown center evaluated in tubers over 336 g.

⁴Cooked and rated after 3 months storage at 4.4 C and 10.0 C using the Snack Food Association color chart, where 1 = very light color, and 5 = very dark color. Acceptable chips are rated 2 or below.

Quality Characteristics

Average tuber specific gravity of Ivory Crisp tubers grown in Idaho, Oregon, and Washington was 1.080 or above, but slightly lower than the average for Atlantic tubers (Table 1). The same comparison trend was expressed in the early harvest Oregon trials (Table 2) and in the eastern Idaho late trials (Table 3). Tuber specific gravity for Ivory Crisp in all trials was consistently in the range considered acceptable for potato chip production. The lowest single trial measurements were in 1989 and 1990 in Oregon (Table 1) where the specific gravity was 1.078.

Ivory Crisp has shown good resistance to most internal and external defect problems. It is markedly more resistant to hollow heart and internal brown spot than Atlantic, and slightly less resistant to shatter bruise and growth cracks (Table 4). Although the average shatter bruise score for Ivory Crisp would indicate a tendency for resistance, in some trials, when conditions were conducive to injury, shatter bruise on Ivory Crisp was very severe. In observations at Aberdeen, Idaho, Ivory Crisp seldom or never developed defects associated with stem-end discoloration or second growth. It is also resistant to blackspot bruise, as established using both abrasive peel tests and post-handling assessments.

Excellent chip color following storage is a desirable characteristic of Ivory Crisp (Tables 3 and 4). It produces chips with lighter color than either Atlantic or Chipeta after storage at 4.4 or 10.0 C. The average chip score for Ivory Crisp following storage at 4.4 C approached the acceptable level,

while those of Atlantic and Chipeta were clearly unacceptable. Ivory Crisp has also demonstrated a strong ability to recondition following the development of color problems (data not shown). The cold-sweetening response of Ivory Crisp follow-

ing storage has been similar to that of Snowden, NorValley, and Dakota Pearl, varieties that are considered to be modern cold-sweetening resistant varieties (Sowokinos and Glynn 2002).

TABLE 4—*Internal and external tuber characteristics and chip color of Ivory Crisp and Atlantic grown in late-harvest trials in Idaho, Oregon, and Washington.*¹

Cultivar	Growth Cracks ²	Shatter Bruise ³	Hollow Heart ⁴	Internal Brown Spot ⁵	Chip Color ⁶		
					4.4 C	7.3 C	10.0 C
			-%	-%			
Ivory Crisp	4.3	3.6	3	0	1.1	1.2	2.3
Atlantic	4.6	3.8	19	5	1.5	1.4	3.1

¹Includes trials at Aberdeen, Idaho (4 years), Hermiston, Oregon (4 years), and at Othello, Washington (3 years).

²Growth cracks rated 1-5 with 1 = severe, 5 = none.

³Shatter bruise rated 1-5 with 1 = severe, 5 = none.

⁴Incidence of hollow heart reported as a percentage of tubers over 336 g with visible hollow heart and/or brown center symptoms.

⁵Incidence of internal brown spot (heat necrosis) reported as a percentage of tubers over 336 g with symptoms.

⁶Chip color rated using the Snack Food Association color chart, where 1 = very light color, 5 = very dark color. Acceptable chips are rate 2 or below. Chips were cooked and rated after 3 months storage at 4.4 C and 10.0 C at Aberdeen, Idaho, and at 7.3 C at Hermiston, Oregon.

TABLE 5—*Disease reactions of Ivory Crisp, Atlantic, and Chipeta.*¹

Cultivar	Common Scab	Vert. Wilt	Foliar Early Blight	PXV	PVY	PLRV	Net Necrosis
Ivory Crisp	5	5	7	7	7	7	2
Atlantic	3	4	7	1	7	7	2
Chipeta	2	2	5	7	7	7	2

¹Disease response rated 1-9 where 1 = very resistant and 9 = very susceptible. Values were based on controlled field screening studies. Ratings are a composite of 1-3 years of screening trials conducted at Aberdeen (common scab, vert. wilt, and foliar early blight, and Kimberly, Idaho (PVX, PVY, PLRV, and net necrosis).

TABLE 6—*Biochemical analyses of Ivory Crisp, Atlantic, and Chipeta tubers.*¹

Cultivar	Dry Matter	Sucrose ²	Dextrose ²	Protein ²	Vitamin C ²	Total Glycoalkaloids ²
	-%	-%	-%	-%	- mg 100 g ⁻¹	- mg 100 g ⁻¹
Ivory Crisp	23.2	0.18	0.02	6.9	17.6	3.9
Atlantic	24.0	0.18	0.06	6.1	17.6	7.4
Chipeta	22.7	0.19	0.06	6.3	20.4	4.4

¹Data derived from tubers grown at Aberdeen, Idaho, in 1989, 1992 and 1994-95. Tubers were stored for 1 month at 7.3-12.7 C prior to sample preparation. All samples were cubed, freeze-dried, and ground prior to analyses.

²Sucrose, dextrose, vitamin C and glycoalkaloids determined on the fresh weight basis, protein determined on a dry weight basis.

Disease Reactions

Ivory Crisp is susceptible to most common field diseases of potato, including common scab, foliar early blight, Verticillium wilt, PVX, PVY, and PLRV (Table 5). It was very susceptible to both the foliar and tuber phases of late blight when tested at Mt. Vernon, Washington, and Corvallis, Oregon. Recent field tests have also shown Ivory Crisp to be very susceptible to pink rot and powdery scab. Ivory Crisp is resistant to tuber net necrosis induced by PLRV. It has shown typical symptoms following infection with bacterial ringrot and strong symptoms, without a latent tendency, when infected with PVY. Ivory Crisp is susceptible to common potato storage rots but has not shown unusual problems in storage.

Biochemical and Nutritional Characteristics

In analyses conducted as part of the Western Regional Trials, tubers of Ivory Crisp were intermediate in dry matter between Atlantic and Chipeta (Table 6). The sucrose content of Ivory Crisp tubers was similar to that of Atlantic and Chipeta, while dextrose was lower, and protein higher. Tubers of Ivory Crisp were lower in vitamin C than those of Chipeta. Tubers of Ivory Crisp were consistently lower in total glycoalkaloids than either Atlantic or Chipeta.

Usage

Ivory Crisp was bred for and is suited to the manufacture of potato chips. It can be marketed directly from the field as an early or late-harvested crop, or following storage. Although intended for chipping, Ivory Crisp can be used as a tablestock potato and produces acceptable boiled and mashed products with little sloughing during cooking.

Management

Based on disease reactions and studies on management of Ivory Crisp conducted primarily in southeastern Idaho, the following management practices are recommended. Soils infested with root-knot or stubby root nematodes, or with a history of early dying, should be fumigated. Only certified seed should be planted to minimize yield-reducing virus problems. Seed should be cut within the size range of 40 to 70 g (1.5 to 2.5 oz) and treated with a fungicidal seedpiece treatment.

Ivory Crisp requires a relatively large amount of nitrogen fertilizer to maximize yields. The optimum application rate in southeastern Idaho has been 258 to 303 kg N/ha (230 to 270 lbs N/acre) for a full-season crop. About 80% of the total nitrogen fertilizer should be applied by the time the first flush of flowers is gone. Petiole nitrate nitrogen content should be at 17,000 to 20,000 ppm prior to tuber set, 13,000 to 18,000 ppm during tuber set and early bulking, and allowed to fall to 7,000 to 9,000 ppm by the onset of senescence. Nitrogen fertilizer applications on potatoes destined for early harvest should be reduced by as much as 25% from the rates recommended for full-season production.

Under threat of infection with late blight, an effective fungicide program should be followed. In late-blight infected fields, tubers of Ivory Crisp should be inspected for tuber rot before going into long-term storage. Ivory Crisp has relatively short dormancy (similar to Atlantic), and sprout inhibitors should be applied within two months after harvest to maintain minimal sprouting. If sugars accumulate above optimal levels, Ivory Crisp tubers can be effectively reconditioned by raising the storage temperature to between 12 and 15 C for 2 to 3 wk.

Availability

An application for Plant Variety Protection has been filed for Ivory Crisp. Seed is available from potato seed growers in Idaho, North Dakota, and Canada. Small amounts of seed, for research purposes, can be obtained by contacting the corresponding author, Dr. Stephen Love.

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